

MOTION AND TIME STUDY ANALYSIS OF WOODEN LOCALLY MANUFACTURED DUPLICATING MACHINES.

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ABSTRACT

Studies were carried out on time-and-motion-economy of wooden locally manufactured duplicating machines. Two versions of the machine were used for the study, viz: standard version and semi-mechanized version. Working with both auxiliary and routine operations, the standard duplicator produced printed paper at an average time of 74.1 seconds, while the semi-mechanized duplicator recorded an average time of 54.3 seconds. Eliminating all auxiliary operations associated with the semi-mechanized machine, 6.92 seconds was achieved as the standard time for one duplicating process.

Key words: duplicating machine, time-and-motion-economy, semi-mechanized, standard, wooden.

INTRODUCTION

Most tasks can be performed in different ways. It is apparent that effectiveness of a piece of work will be a function of the utilized method in carrying out the prescribed work. Morris (1976) reported that, the development of the methods of work in industrial organizations is largely in the hands of the industrial engineer. This is understandable since many industrial processes require technical knowledge relative to the design and operation of various machines.

The approach of the engineer to problems in work methods has been termed "time-and-motion-economy" (Barnes, 1968). This analysis is designed to reveal how the movement of the body could be improved to bring about an increase of productiveness in the work; with possible modification of the utilized equipment. The time of each operation is analysed, unnecessary movements are noted and eliminated. New movements or new combinations of old effective movements are suggested. Munde (1977) define motion and time study as a broad branch of knowledge dealing with the systematic determination of preferable work methods, with the appraisal, in terms of time, of the value of work involving human activity, and with the development of material required to make practical use of these data. There are two broad principles that govern this realization. These principles are: motion study and time study. The motion study aspect according to Mundel (1988), consists of systematic analysis and improvement of work methods, considering the equipment design and human activities used in performing

each step of the work. Other factors of consideration according to Floyd and Roberts (1985) include design of the outputs, the process or order of work, utilized tools, work-place and equipment for each step in the process, and selected raw materials. The aim according to Akpan (2001a) is to determine (or design) a preferable work method. The criterion of preference is usually economy of money (Akpan, 2001b). However, effectiveness of the activity, accuracy, reliability, ease or economy of human effort, economy of time, and economy of material frequently take precedence (Floyd and Roberts, 1985). On the other hand, time study involves a wide variety of procedures for determining the amount of time required, under certain standard conditions of measurement, for tasks involving some human, machine, or combined activities (Das, 1990).

Hines (1977) established that it is difficult to separate completely the two areas of motion study and time study in as much as a specified method, frequently in the form of a written standard practice or procedure, employing one of the techniques of motion study is one of the conditions of time measurement. Also, time measurement according to him is often a part of the basis on which alternative methods are compared. In addition, method determination and time appraisal complement each other's utility in application. The combined term-motion and time study is used to denote all three phases of activity: method determination, time appraisal, and the development of materials for the

Table 1: Activity Chart for the Operations of the Standard Version Duplicator
(Workers in Group A).

No. of opts	Description of Activity	WORKERS					AVERAGE TIME (S)	S.D.
		I	II	III	IV	V		
1	Open the frame with handle through 180°	3.40	3.60	3.50	3.40	3.40	3.46	±0.17
2	Open the door through 90°	2.10	2.20	2.20	2.10	2.00	2.12	±0.16
3	Feed-in the ink into the foam through the felt pad	37.90	40.10	40.00	39.00	38.40	39.08	±1.94
4	Fit-in the cut-stencil against the felt pad on the frame with handle	8.40	8.80	8.60	8.30	8.50	8.52	±0.38
5	Place the duplicating paper on the paper-base	1.60	1.70	1.60	1.60	1.60	1.62	±0.09
6	Regulate the paper-guide-bars to accommodate the paper in precise position	10.30	10.80	10.90	10.60	10.70	10.66	±0.46
7	Press downwards the frame with handle against the paper base to obtain the printing result	3.60	3.80	3.50	3.60	3.60	3.62	±0.23
8	Open the frame with handle through 180°	3.40	3.50	3.70	3.40	3.40	3.48	±0.26
9	Remove the duplicated paper	1.60	1.60	1.60	1.50	1.40	1.54	±0.18
	Mean operating time (seconds)	72.30	76.10	75.60	73.50	73.00	74.10	±3.33

application of these data in all fields of human and machine activities (Hines, 1977).

The field of application of motion and time study as described by Carson (1984) include finding a preferred way of doing work and assisting in effectively managing or controlling the activity. The approach of motion and time study fits equally well when applied to heavy or light factory, office, production, maintenance, staff, or any supervisory work. It is equally applicable to farm work, housework, surgery, cafeteria work, the whole range of government activities, departmental store or hotel work, battle activities, or any other human activities (Carson, 1984).

Barnes (1968) as cited by Akpan (1991) further defined motion and time study as the systematic study of work systems with the purpose of determining the standard time required by a qualified and properly trained person working at a normal pace to do a specific task or operation. This time standard may be used for planning and scheduling work for cost estimating, in terms of labour cost control and as the basis for wage incentive plan. In the early twentieth century, time standard was sometimes converted into money value and was called a piece rate. Piece rates were usually expressed in terms of money used as means of paying workers (Ellis, 1989).

McCormick (1976) reported that motion-time data are widely used in work sampling for establishing time standards using the stopwatch. The operation to be studied is divided into small elements, each of which is time with a stopwatch. A selected or representative time value is found for each of these elements, and the times are added together to get the total selected time for performing the operation. The speed exhibited by the operator during the time study is rated or evaluated by the time study observer and the selected time is adjusted by this rating factor so that a qualified operator, working at a normal pace, can easily do the work in the specified time. This adjusted time is called the normal time, which is standardized.

The objective of this paper is to understudy the time and motion economy of wooden locally manufactures duplicating machines, designed by Akpan (2001a), with a view of standardizing the time required to achieve one duplicating process. This study becomes most imperative as observation in the course of operating the machine suggests that unnecessary movements could be eliminated to increase the productivity of the machine.

METHODOLOGY

Two versions of the wooden duplicating

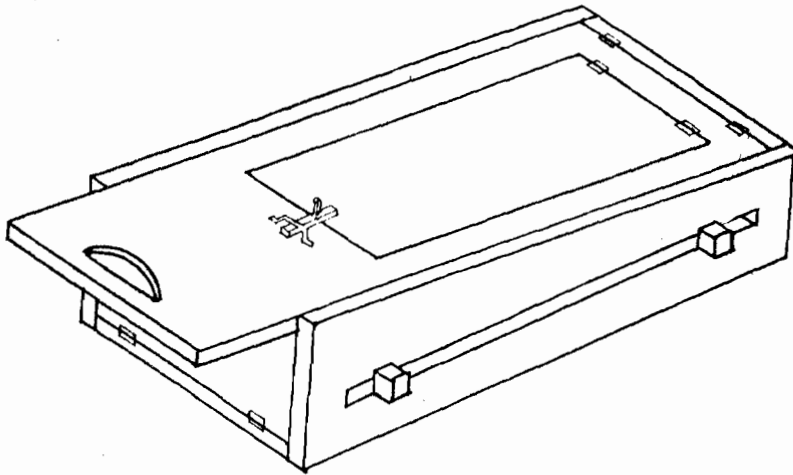


Fig. 1: Pictorial View in Isametric Projection
Source: Akpan (2001a)

machine were produced for the study, viz: the standard version and the semi-mechanized version. Akpan (2001a) depicts the detail design, constructional procedures and operational techniques of the machine. Figure 1 shows the pictorial view of the machine in isometric projection, while Appendices A and B indicate its summary constructional procedure and operational techniques respectively. Although the process chart and flow diagram could give a picture of the various steps in the operations of the machines, it is often desirable to have a breakdown of the processes or series of operations plotted against a time scale as the machines are in operation. This is with a view of determining the standard time required to perform a specific task with the machines. Accordingly, in order to obtain average values of the time scale plotted against each operation necessary to realize the duplicating process, in function of the type/design of the duplicators; two groups of workers were provided. These were classified as follows: group A workers and group B workers.

Workers in group A worked with the standard version duplicator, while workers in group B worked with the semi-mechanized version duplicator. Each group had five workers selected randomly to reflect different heights, weights and ages. The selection was done by grouping twenty five workers into five different groups in function of their heights, weights and ages. Each group contained five workers. An index number was allotted to each worker in each of the groups. Replica numbers were placed in a container. The container was vigorously shaken before numbers were picked from it. The picked number for a particular group qualified the worker, bearing that number for selection.

The heights of the considered twenty five

workers were 1.68, 1.66, 1.59, 1.58, 1.62, 1.66, 1.67, 1.70, 1.62, 1.63, 1.65, 1.72, 1.70, 1.58, 1.64, 1.69, 1.63, 1.71, 1.73, 1.61, 1.60, 1.68, 1.64, 1.66 and 1.70 metres; their weights were 69, 60, 63, 64, 61, 60, 53, 71, 73, 64, 75, 55, 69, 66, 62, 76, 58, 66, 79, 56, 55, 67, 66, 65 and 68 kilogrammes; while their ages were 15, 16, 17, 18, 19, 21, 22, 23, 26, 28, 30, 31, 34, 37, 38, 42, 44, 46, 47, 48, 50, 52, 55, 57 and 58 years respectively. However, the heights of the five selected workers were 1.61, 1.64, 1.66, 1.69 and 1.66 metres; their respective weights were 63, 64, 69, 66 and 75 kilogrammes; while their corresponding ages were 18, 23, 30, 46 and 50 years.

The execution of the operations of the duplicating processes with the machines were carried out by each of these workers. The time for each worker to complete each operation, as well as the duplication process were recorded by means of the stopwatch. Tables 1 and 2 show the activity charts for the processes of operations of the duplicators. Table 1 shows the activities of group A workers, working with the standard version duplicating machine, while Table 2 depicts the activities of group B workers, working with the semi-mechanized duplicator, which is an improvement of the standard version duplicator.

RESULTS AND DISCUSSION

The results of the systems analyses as shown in the activity charts (Tables 1 and 2) reveal that operation 1 (opening the frame with handle through 180°) with the standard version duplicator was eliminated. The elimination was affected by the provision of two springs each of 12cm in length at the back of the frame with handle (Akpan, 2001a). These springs

Table 2: Activity Chart for Operations of the Semi-Mechanized Version Duplicator (Workers in Group B)

GROUP B: SEMI-MECHANIZED DUPLICATOR		WORKERS					AVER. TIME (S)	S.D.
No. of ops	Description of Activity	I	II	III	IV	V		
		Time (seconds)						
1	Eliminated	-	-	-	-	-	-	-
2	Eliminated	-	-	-	-	-	-	-
3	Feed-in the ink into the foam through the felt pad	37.90	40.00	39.10	39.00	38.50	38.90	±1.60
4	Fit-in the cut-stencil against the felt pad on the frame with handle	8.40	8.60	8.60	8.40	8.40	8.48	±0.22
5	Place the duplicating paper on the paper-base in line with the marked lines	1.60	1.60	1.70	1.60	1.60	1.62	±0.09
6	Eliminated	-	-	-	-	-	-	-
7	Press downwards the frame with handle against the paper base to obtain the printing result	2.00	2.10	2.10	2.00	2.00	2.04	±0.11
8	Frame with handle returns back to original position of opening	1.80	1.80	1.80	1.80	1.80	1.80	-
9	Remove the duplicated paper	1.40	1.60	1.60	1.30	1.40	1.46	±0.27
	Mean operating time (seconds)	53.10	55.70	54.90	54.10	53.70	54.30	±2.04

permanently left the frame open, thus saving the time required to perform this activity of opening the frame with handle through 180°.

Also eliminated was operation 2 (opening the door through 90° with the standard version duplicator). Since provision has been made for the frame with handle to be permanently opened, it implied that the door of the machine remained permanently opened (this possibility was because the ball-catch is between the door and the frame with handle) (Akpan, 2001a). This of course eliminated constant opening of the door through 90°, thus, saving the time of that operation.

In the same vein, opening 6 (regulating the paper guide bars to accommodate the paper in precise position) with the standard duplicator was also eliminated. This was done by regulating the paper guide-bars once. After which lines were marked on the paper-base to permanently gauge the position where the papers will constantly be placed (Akpan, 2001a). This eliminated the time of frequently gauging the proper position of the paper by trial and error.

In addition, the time of performing operation 7 (press downwards the frame with handle against the paper base to obtain the printing) with the semi-mechanized duplicator was considerably reduced, since the springs at the back of the frame with handle has reduced the angle of opening from 180° to about 45°. This also reduced the rate at which the frame with handle returns back to its original position of

opening (operation 8, semi-mechanized duplicator) (Akpan, 2001a).

Eliminating auxiliary operations such as 1, 2 and 6; and operations 3 and 4 occurring spasmodically, the remaining operations are the normal routine operations necessary for the duplication process, which include operations 5,7,8 and 9. It is on the bases of these normal routine operations that the standard time to effect a duplicating process was finally estimated. The breakdown is shown in Table 3.

Table 3: Estimated Average Standard Time (seconds) to produce One Duplicated Paper With Normal Routine Operations

Operation No.	Time (Seconds)
5	1.62
7	2.04
8	1.80
9	1.46
Total Average Time	6.92

Thus, the standard time for duplicating one printed paper was recorded to be 6.92 seconds.

CONCLUSION

From the activity charts, motion and time economy involved the retention of those movements in an older method of work (standard duplicating process), the strenuous movements and periods of inactivity were eliminated. By

exponents of the old method, the resultant new method of work (semi-mechanized duplicating process), not only gave higher productivity value, it also established the exact standard time needed to complete the specific work.

Thus, production plans of this newly invented machine can be re-adjusted on the basis of this established work schedule.

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Appendix A: Summary Constructional Procedure of the Wooden Duplicating Machine as Published by Akpan (2001a)

All the wooden members were cut to specifications by means of the power circular saw machine. Using the horizontal drilling machine, slots were made for the paper guide bars on each of the sides. Grooves were also provided on each interior surface of the sides for the purpose of accommodating the paper-base. With adhesives and nails, the sides were fitted onto the paper-base.

Thereafter, the paper guide bars were introduced into the previously cut slots on the sides. Wooden supports were fitted at the ends of the paper guide bars by means of screws. The back was then mounted to the sides using common nails. The bottom of the machine carrying the double ball-catch was hinged-in, glued and nailed onto the sides. Similarly, the hinged-in frame with handle carrying the wrapped foam-carrier with the flush-bolt and felt-pad was nailed to the back of the machine. Akpan (2001a) contains the cutting list/specifications for the production of the machine.

Appendix B: Operational Techniques of the wooden Duplicator According to Akpan (2001a).

The information to be reproduced is cut in a stencil. The stencil may be cut by a typewriter or by hand, using a stylus pen. The frame with handle is then opened in such a way that the wrapped foam is facing upwards. Ink is fed into the wrapped foam through the felt pad. The door is left in an opening position to give clearance to the frame with handle.

Against the felt pad, the stencil is clipped onto the frame with handle. The clipping is effected by means of the clipper (mechanical fastener) at the bottom of the frame with handle, and also cello-taped onto the frame at the upper part. On the paper-base, the paper to be duplicated upon is placed and precisely gauged into proper position using the paper guide bars. The frame with handle is then pressed against the paper-base, where the paper was placed.

By the principle of adhesion, the ink is transferred onto the cut stencil, which in turn appears on the paper. The labelled operational drawing in isometric projection is contained in Akpan (2001a).